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FINAL REPORT

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Measurement of Optical and Radiative Properties
of High-Temperature Materials by FTIR Spectroscopy

Reporting Period
December 21, 1994 through December 20, 1995

for

NASA/MSFC
Marshall Space Flight Center
Huntsville, AL 35812

by

Containerless Research, Inc.
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1. Summary

This is the final report on the subject project. The objective of the project was to assist in experiments to be performed at MSFC in which FTIR spectroscopy will be used to measure emissivities of high temperature materials. The measurements of interest are obtained under containerless conditions achieved in an electromagnetic levitation and heating apparatus at MSFC. CRI scientists participated in the design, software selection, and sensitivity analyses for the experiments as well as further proposal preparation by MSFC in the project area. We also analyzed experiment designs, designed a custom optical system for collection of light from the specimens, designed calibration experiments, and specified FTIR and optical equipment. The following major tasks were completed: (i) ray-tracing of the optical layout of the FTIR system with modifications resulting from changes to the EM levitation system, (ii) developed the entire mechanical system for the FTIR optics, (iii) supplied the designs to MSFC for construction.

The research is part of a continuing collaboration of Dr. Robinson of MSFC and Dr. Krishnan of CRI to measure emissivities of high temperature materials.

The work was scheduled to be completed over a period of twelve months. It was completed within nine months. During the first three months of the project, Dr. Krishnan, performed (i) preliminary ray-tracing of the optical layout of the FTIR system, (ii) investigated the availability of suitable software, (iii) assisted Dr. Robinson in the preparation of a NRA research proposal, and (iv) conducted sensitivity analyses of the measurement system to be developed.

The ray tracing work involved laying out the FTIR system and selecting suitable off-axis focussing mirrors for re-collimation of the image from the specimen in order to fill the instrument aperture. A pair of off-axis parabolas will be used with an intermediate movable field stop to achieve the desired collimation. The collimated beam will be allowed to enter the FTIR.

The availability of suitable software for Kramers-Kronig analysis (using integral equations) and for sum-rule analysis (using numerical integration) was investigated. A C-language mathematical library (CSL) and a windows-based stand-alone package (Mathematica) were selected.

Sensitivity analyses of the FTIR measurement system were conducted, including the effects of (i) temperature and emissivity errors, (ii) focussing errors, and (iii) interference from background radiation.

During the second quarter of the project, the work included the following major tasks in support of the FTIR project: (i) completed final ray-tracing of the optical layout of the FTIR system, (ii) selected and acquired Mathematica and Optic, for data analysis and optical analysis, (iii) developed a preliminary design for the optical system to be used in conjunction with the FTIR system.

Further sensitivity analyses of the FTIR measurement system were conducted, including the effects of (i) temperature and emissivity errors, (ii) focussing errors, and (iii) interference from background radiation.

The project was completed during the third quarter. The work included the following major tasks in support of the FTIR project: (i) completed ray-tracing of the optical layout of the FTIR system with modifications resulting from changes to the EM levitation system, (ii) developed the entire mechanical system for the FTIR optics, and (iii) supplied the designs to MSFC for construction.

The ray tracing work involved laying the FTIR system out and selecting suitable lenses, off-axis paraboloid mirrors for re-collimation of the image from the specimen in order to fill the instrument aperture. A ZnSe lens and an of off-axis parabolas will be used to provide an image of the specimen at the field stop. A second parabola recollimates the light emerging from the field stop and a fourth mirror directs the output beam into the FTIR. Provisions were made for viewing of the field stop with a video camera, and for adjustments of the mirrors to allow selection of different points in the field of view (needed for calibration).

A detailed letter outlining the features of the design was also submitted. In addition, D-size, machine shop ready drawing have been provided. Copies of catalog pages for component purchases have also been provided. Discussions are also on-going with MSFC personnel with regards to the design and some slight modifications. These efforts will continue over the rest of the year.

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13. ABSTRACT (Maximum 200 words)

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